A Systems Perspective for Assessing Carbon Dioxide Capture and Storage Opportunities

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Geographic Information Systems

- Geographic Information System (GIS)
  - Tool to model, analyze and visualize spatial relationships between data
  - Composed of computer programs, data, and personnel
  - Increasingly used in areas of spatial analysis

MIT's Carbon Management GIS

- Overall Project Objectives
  - Integrate information from diverse sources
  - Conduct systems analysis and modeling
  - Inform and support policy decisions
- Data
  - Technical data
    - » CO_2 infrastructure (sources, sinks, transport)
    - » Topography (elevation, rivers, land type)
  - Political data (demographics, sensitive areas)
  - Economic data (cost algorithms)
  - Regulatory data (permitting)

Project Objective

To develop a systems framework to analyze and evaluate geologic sequestration options

Approach

- Characterize CO_2 Sources
- Characterize Storage Reservoirs
- Match CO_2 Sources to Storage Reservoirs
- Systems Analysis

Characterize CO_2 Sources

- Key CO_2 Sources
  - Fossil fuel-fired power plants
  - Industrial processes
- Outputs for Systems Analysis to GIS
  - Costs
  - CO_2 Quantity
  - CO_2 Quality

Characterize CO_2 Sources

- Major Parameters
  - CO_2 flow rates
  - CO_2 purity
  - CO_2 Pressure
  - "Retrofit parameters", e.g., fuel, process, physical layout
- Levels of analyses
  - Current – Costs for generic plants or user input
  - Future – Case-by-case analysis
    - » Depends on availability of detailed data
    - » Depends on availability of appropriate algorithms

Characterize CO_2 Reservoirs

- Key CO_2 Reservoirs
  - Oil and gas reservoirs
  - Unmineable coal seams
  - Deep saline formations
- Outputs for Systems Analysis to GIS
  - Costs
  - Capacity
  - Special Requirements (e.g., purity)
  - Future – regulatory/political requirements

Characterize CO_2 Reservoirs

- Major Parameters
  - Porosity
  - Depth
  - Pressure
  - Permeability
  - Thickness
  - "Containment parameters"
- Levels of analyses
  - Desired – calculations based on actual data
  - Alternate 1 – Extrapolate "play" data
  - Alternate 2 – Use default data

Match CO_2 Sources to Storage Reservoirs

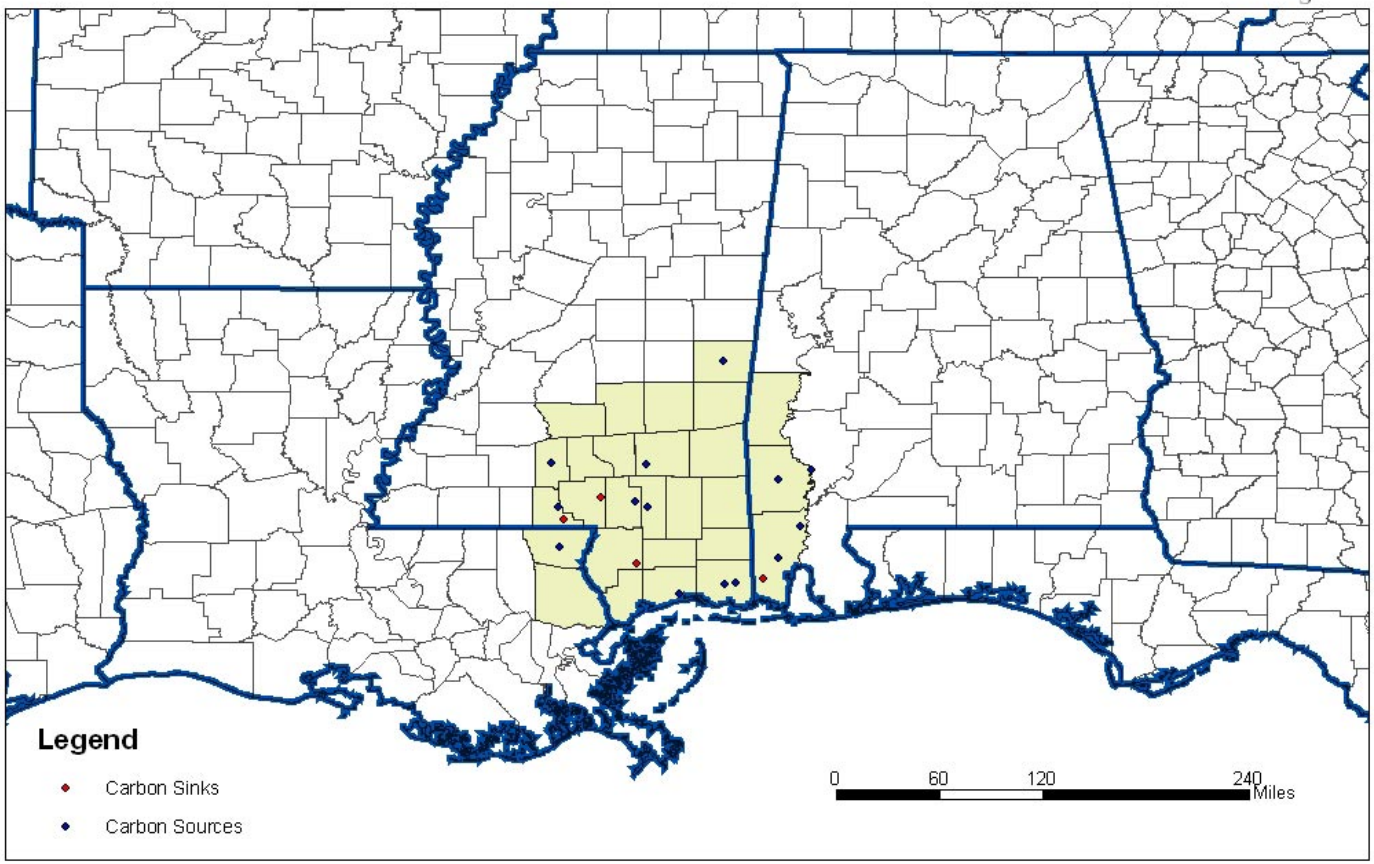
- Consider only pipelines
  - Straight line path
  - Consider topography, population centers, etc.
  - Follow existing rights of way (e.g., power lines, gas pipelines, railroads)

Systems Analysis

- Key parameters
  - Cost
  - Capacity
  - Regulatory/Political
- System Options
  - Best storage reservoir for a single CO_2 source
  - Design for multiple CO_2 sources/ storage reservoirs
  - Optimization for multiple CO_2 sources/ storage reservoirs

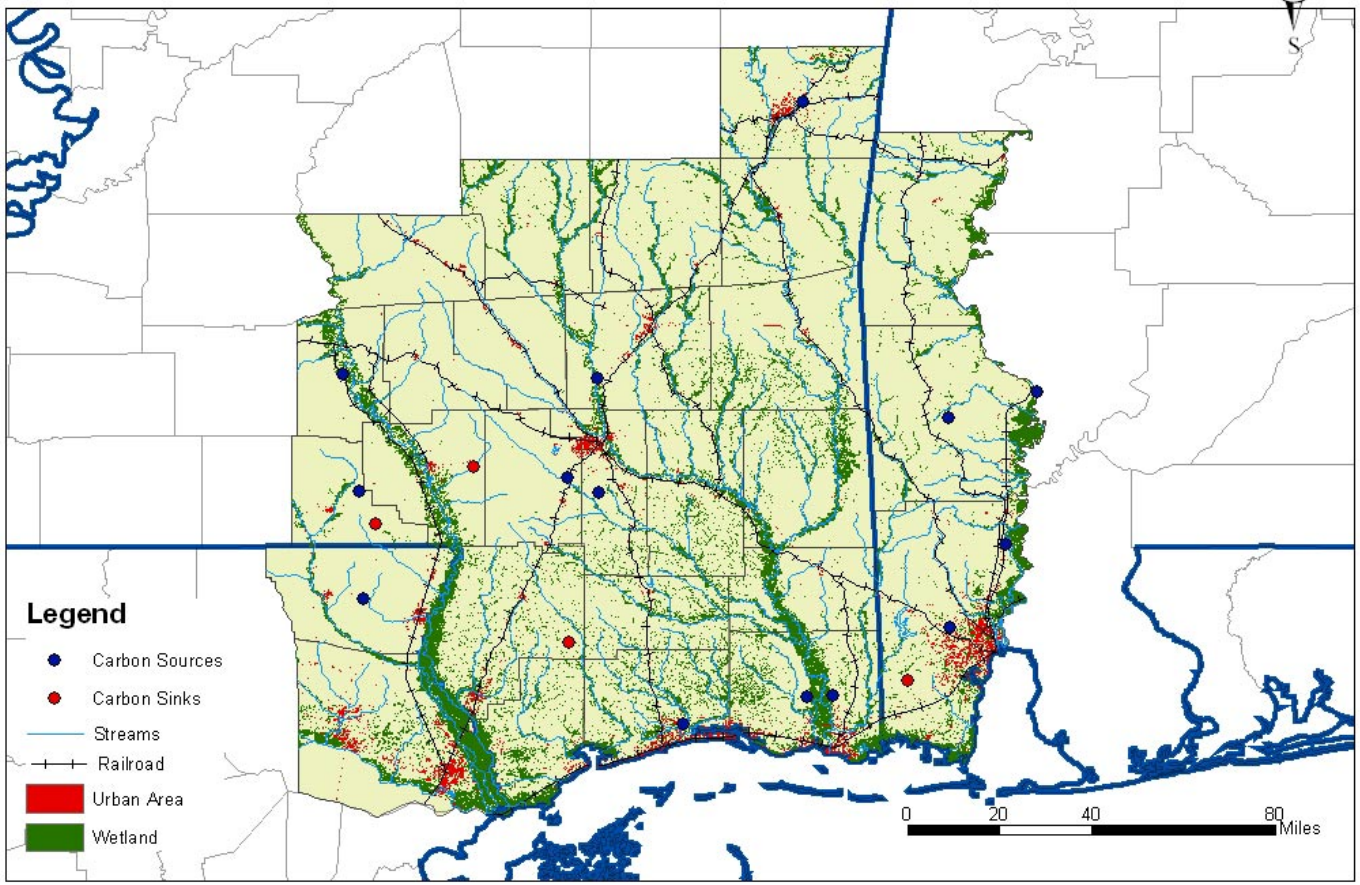
Case Study

Figure 1 Sinks and Sources in the Study Area

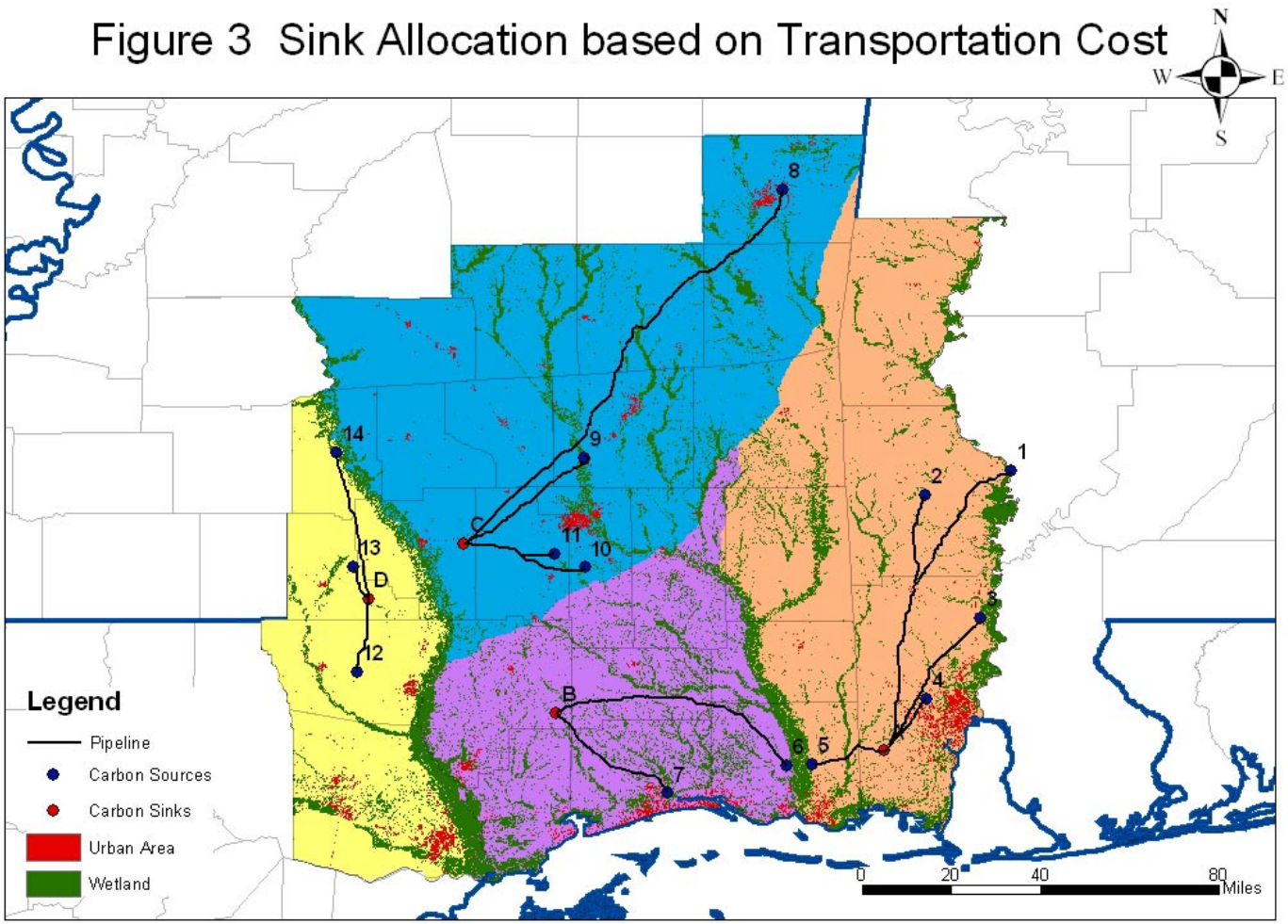


Topography

Figure 2 Transportation Obstacles in the Study Area

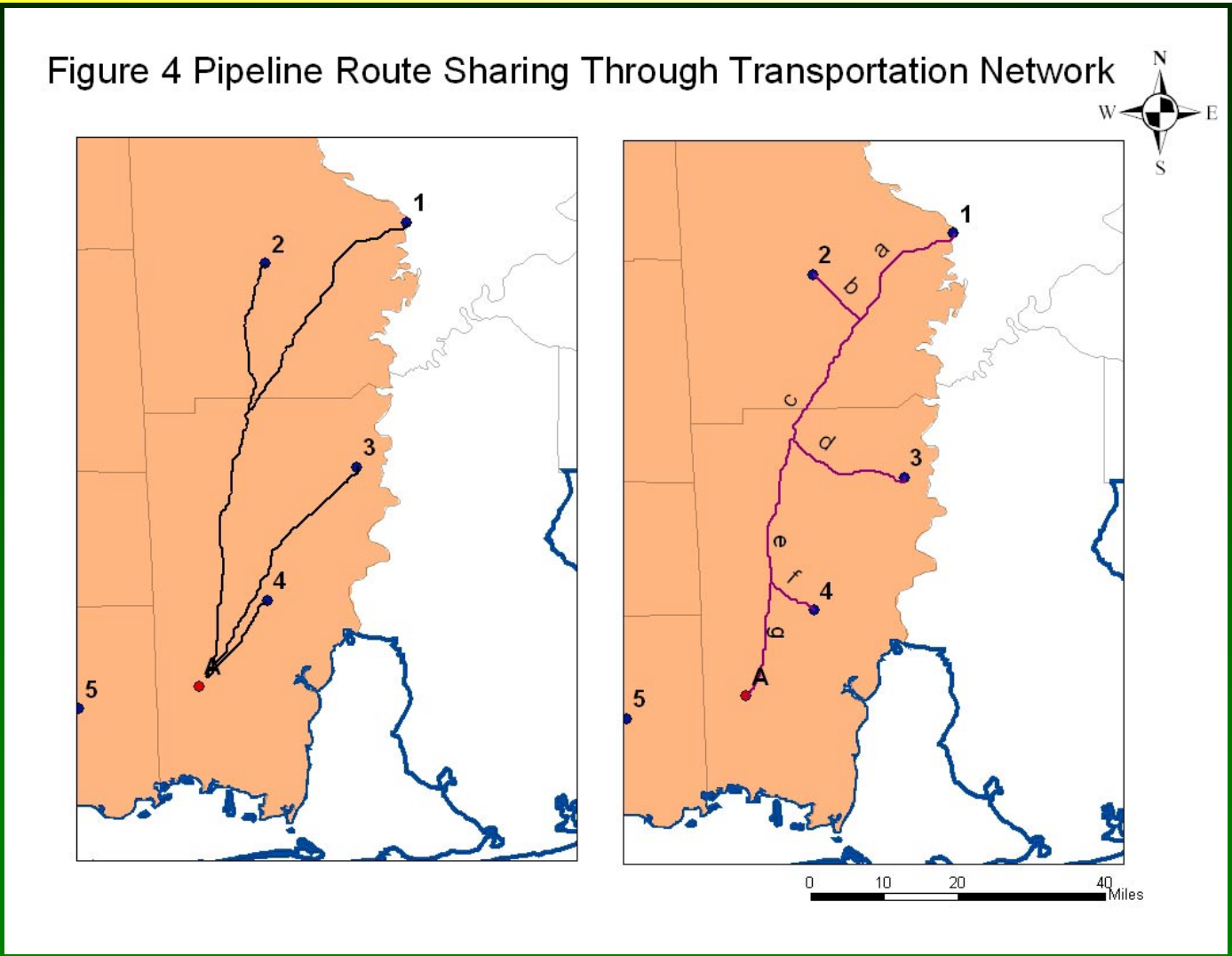


Best storage reservoir for a single CO_2 source



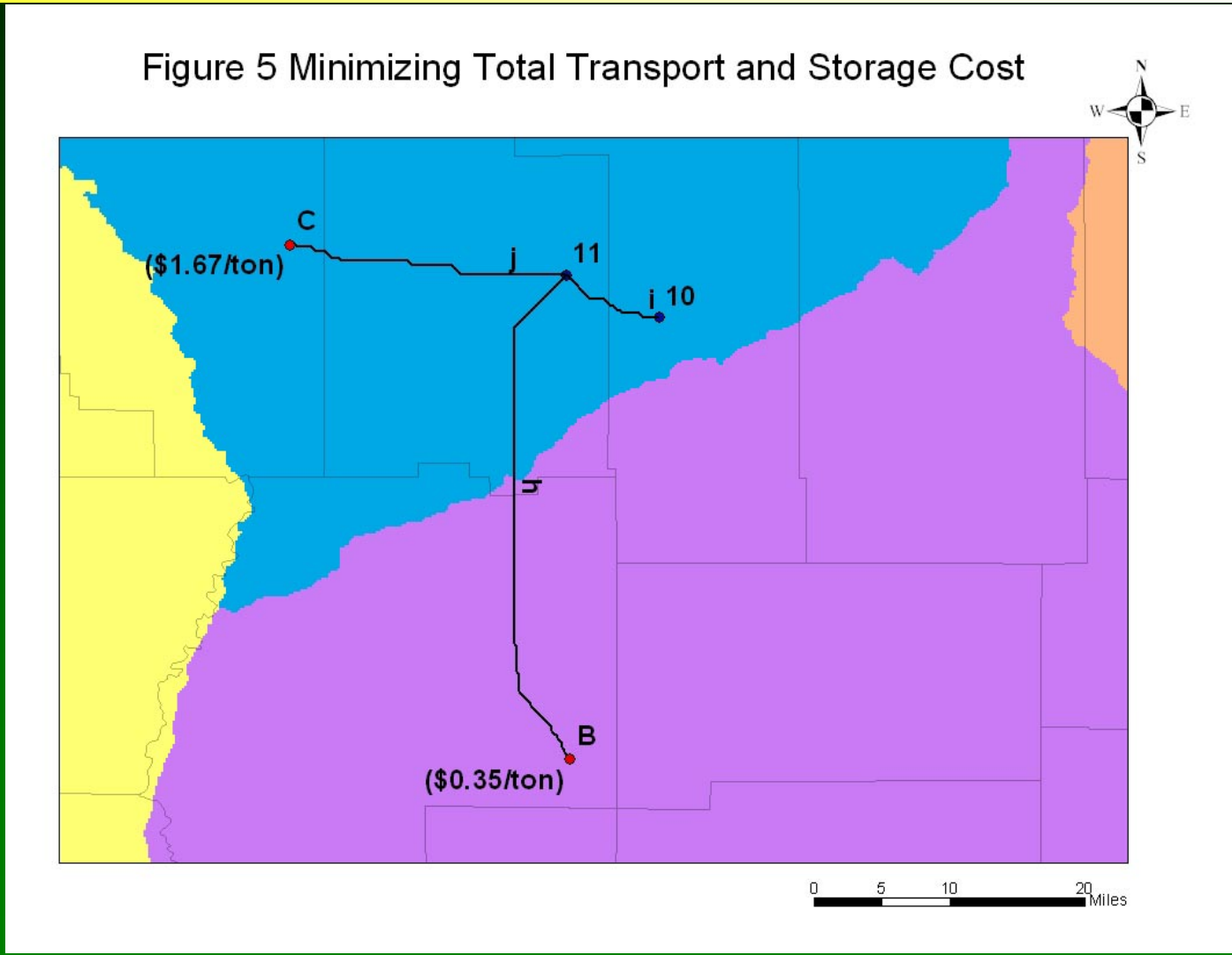
Design for multiple CO_2 sources/ storage reservoirs

Transportation Cost $ 0.86 /t CO_2



Transportation Cost $ 0.63 /t CO_2

Design for multiple CO_2 sources/ storage reservoirs



Conclusions and Recommendations

- GIS is a promising tool to conduct systems analyses for carbon capture and storage opportunities
- Biggest need is for better data – both depth and breadth (hopefully the Regional Partnerships and NATCARB will help here)
- Work is continuing to develop more detailed algorithms for evaluation & optimization

Acknowledgement

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- Also thanks to Henry Zhang for implementing the approaches discussed in this paper.

- Further information about the MIT Program on Carbon Capture and Storage can be found at <sequestration.mit.edu>